PUBLIC WORKS DEPARTMENT MALAYSIA
CONSTRUCTION AND MAINTENANCE
(ENSURING ROAD QUALITY IN MALAYSIA)

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ABSTRACT

It is widely recognized that a good road infrastructure of a country is a pre-requisite to the development of a nation. Besides constructing new roads in Malaysia, Road Authorities are now aware of the needs to maintain and upkeep the existing roads in hand. With the large road network currently at about 17,500 km for Federal Roads and about 61,000 km for the state roads in Malaysia, roads maintenance budget accounts for sizeable proportion of public expenditures and is currently at about RM 580 million a year. If road user costs or vehicle operating costs (VOC) are taken into considerations, the total expenditure by road transport sector is even greater.

Federal road maintenance has been privatized since 2001 for 15 years. It was divided into 3 zones namely northern, southern and central/eastern zones. Before any maintenance activities taken over from the project team, there are few acceptance criteria setup mainly for pavement, bridge and road furniture. For the pavement component, the major parameters considered in the criteria are surface regularity, pothole, crack, rut depth and bleeding. All these criteria are based on the Public Works Department (JKR) standard specification for road construction and must be complied accordingly. For those locations which are not fulfilling the criteria, the project team has the responsibility to rectify all those non-compliance items within the stipulated period. Failure to do so, the JKR has their right to retain the performance bond or engage third party to take action against those defects.

Apart from that, the JKR is now initiate an internal audit to inspect all those new road construction project which is involve both sides i.e. maintenance and project team in order to facilitate both party in handing over the project after Defect Liability Period end.

INTRODUCTION

The road network is a very important asset and acts as an enabler to the economic and social development of a country. In today's world of globalization, the provision of good road network and infrastructure will enhance the nation's competitiveness and maintain an edge over its competitions. In Malaysia, the economic contribution by the road network is enormous as it carries about 96% of transported goods and passengers. Conservation of the road asset condition is therefore very crucial to ensure the network continues to be effective and serves its functions to the required quality standards throughout its lifetime.

Roads in Malaysia are classified into two broad categories, namely Federal Roads and State Roads. Federal roads are all roads declared under the Federal Roads Ordinance (1959). This category of roads includes the National Expressways and Highways under the administration of the Malaysian Highway Authority (MHA).

Currently, Malaysia has more than 80,300km of roads. The roads are divided into three main categories namely Toll Expressways, Federal Roads and State Roads.

Road Categories	Length (km)
Toll Expressways	1,700
Federal	17,500
State	61,100

Table 1 : Road Categories and Length

Figure 1 : Road network in Peninsular Malaysia

Public Works Department (JKR) was established in 1872 to build infrastructure for socio-economic development and political systems of the English government in the Straits Settlement comprising of Singapore, Malacca, Perak, Seberang Perai and Penang. Today, JKR is the foremost technical department in national infrastructure development. JKR provides multidisciplinary expertise that ensures best practice in technical consultancy, project management and asset/facilities maintenance management.

Malaysia is consists of two geographical regions divided by the South China Sea which is Peninsular Malaysia and East Malaysia (Sabah and Sarawak). The two distinct parts of Malaysia share a largely similar landscape in both feature coastal plains rising to often densely forested hills and mountains.

With about 329,758 km2 of total land area, Malaysia has a population of 26 million. The country's population growth is forecast at 2.14% per annum for the period 2001-2020.

The per capita gross national income is about US$4,200 in 2004. The gross domestic product grew at an average annual rate of 6.4% over the period 1991-

2003 and an overall target of 6.5% is considered attainable for the period 2001-2020. This much attained growth is attributed by the transportation infrastructure system provided by the government which accelerates growth and economy. The major mode of transportation in Malaysia is predominantly by road which is influenced by its geographical aspects. The annual number of passengers transported by private cars and buses in 2003 is 1,836 million and 850 million persons, respectively. The share of road transport of passengers comprises 64.8% by private car and 30.0% by bus, as compared to 4.7% by rail transport 2 and 0.5% by air transport. The road transport also moved 303 million tonnes of goods or an overwhelming 96.4% of total freight in 2003 [1].

OBJECTIVE

The objective of the paper is to share the overall condition of road construction in Malaysia, quality assurance and the criteria used in the process of accepting the newly constructed road particularly those funded by the federal government.

HISTORICAL PERSPECTIVE OF ROAD DEVELOPMENT IN MALAYSIA

The earliest roads in Malaysia were built primarily for the purpose of trade, i.e. to provide transportation between the tin and rubber production areas and the ports, and to serve urban, government and business centers. Before the Malay States came under British protection they were backward and underdeveloped. There was no proper system of transport that linked between states. During this period, roads were built without any development plan, purposely to link rubber estates and tin mines to ports or river. The main transportation mode is by bullock-cart. This has created discontinuous road which drought the outline of road network in west coast corridor. With the completion of Kuala Kangsar - Tanjung Malim road in 1887, a cart track was linked from Sungei Ujong to Butterworth. It was possible to make a journey of 365 miles by road from Malacca to Butterworth [2].

There was rapid development after the Federated Malay States of Malaya were formed in 1896. Malaya became the main supplier of tin to the world. After 1900, rubber plantations were started all over the country bringing great prosperity to the people. The revenue from tin, rubber and other products provided the government with money to build roads, bridges, railways and other infrastructures.

At the turn of the 20th Century, only 60% of the total road length of about 1,500 km of all classes was ‘metalled roads’ [1]. It was not until after 1910 that tar3 macadam and other bituminous compounds were introduced in Peninsular Malaysia and in the 1950’s in Sabah. While the west coast of Peninsular Malaysia experienced fast development of road in almost every state, the east coast by contrast experienced very little development. Up until World War II, the

road along the east coast did not form a continuous link. During the same period, road development in the states of Sabah in East Malaysia was limited to 'jeep' tracks and practically no road development in the state of Sarawak. The development of road network in Malaysia had entered to the brighter phases after Malaya gained its independence from British administration in 1957.

GOVERNMENT COMMITMENT TOWARDS THE DEVELOPMENT OF ROAD NETWORK

The development of road network in Malaysia was indirectly initiated and supported by various national policies.

5-Year National Development Plan

After the formation of Malaysia in 1963, subsequent 5-year national development plans incorporated road development as one of the important elements for the overall economic and social development of the country. Figure 2 depicts the growth in the expenditure on road development plans under each consecutive 5-year Malaysia Plan which was formulated from 1966 to 2005.

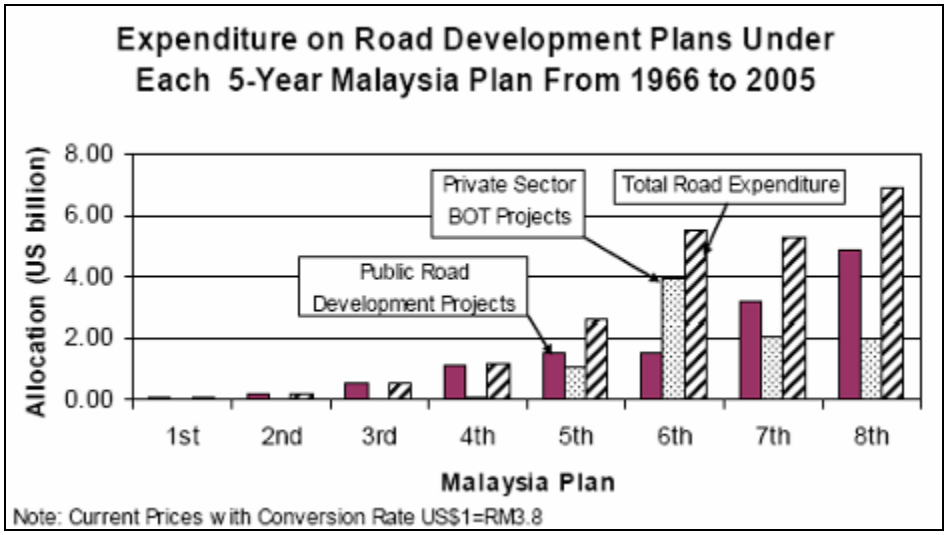

Figure 2 : Growth In The Expenditure On Road Development Plans

MALAYSIAN HIGHWAY NETWORK DEVELOPMENT PLAN (HNDP)

The Highway Network Development Plan (HNDP) Study covering the Peninsular Malaysia, Sabah and Sarawak was completed in 1993. The HNDP Study then identified 72 projects in the Peninsular Malaysia for implementation up till 2010. To date, approximately 36% of the road plans were implemented with some partial completion due to the repackaging of some projects into smaller ones.

Highway Network Development Strategies in Peninsular Malaysia
Four strategies have been identified for the highway network development in Peninsular Malaysia namely:

To rationalise and strengthen the East Coast and the West Coast Networks
The development of road network in both the east coast and the west coast is to sustain the regional economic expansion in order to achieve the target set forth in the Country and the State Economic Development Plans. The strengthening of the road network in the East Coast Corridor includes improving linkages to support the East Coast Highway (Phase 2 is under construction) and the upgrading and widening of Federal Routes 3 and 8 to provide alternative routes for traffic during monsoon season. The East Coast Corridor highway development projects include the improvement of coastal road from Kelantan in the north to Johor in the south.

The existing road network in the West Coast Corridor shall be further strengthened and expanded to meet the traffic demand in future by providing a high level of service and enhance reliability. The development of a new coastal expressway, ring roads and by-passes will be effective in dispersing traffic by relieving through traffic from entering the congested urban centres.

To strengthening the east-west movement
The provision of new linkages for the East-West movement would enhance the development of smaller growth centres. Additional links for the east-west movement will also provide alternative routes for traffic during major road mishaps along the existing roads.

To improve linkages and support growth of regional development area and new entry points
Accessibility to the regional land development schemes located in the Central, Eastern and Southern Development Corridors has to be further improved by linking planned growth centres in the land development schemes to the established regional and administrative centres. Improved linkages would also be provided to new entry points in the north and south to enhance cooperation of border economic activities.

To improve linkage for promoting growth of the Central Corridor
The improvement to the road network in the Central Corridor will provide a definitive and clear road network hierarchy for improving accessibility to eco-tourism centers and other planned agro-forestry based development schemes.

Alternative Highway Network Development Concept Plans
Alternative highway network development concept plans is currently being evaluated and formulated based upon the overlaying of the following considerations :

Fundamental Planning Policy
The fundamental planning policy of the urban hierarchy of urban centres also influences the direction of the road network development policy. The conceptual plan comprises improvement to the present grid ladder to enhance capacity of the road linkages between regional centres and urban centres located within the States.

Socio-Economic and Land use Development Frameworks
Effective linkages are provided for further development of new growth areas and future high economic activity areas in line with the established socio-economic and the land use development frameworks.

Road Development Level
To increase the road development level in each State, a denser road network is provided to meet future traffic demand generated by the increase in socio-economic activities in existing and future growth centres.

Functional Road Network Hierarchy
The new highways and upgrading of existing roads, particularly those highways which have high mixture of local and through flow movements are provided to suit the functional road network hierarchy.

Road Safety Consideration
The improvement of the national highway network through the provision of new highways, and upgrading and widening of roads will enhance road safety by reducing traffic accidents and fatalities.

Environmental Consideration
The highway network development plan shall incorporate the environmental and social requirements by planning new highways to avoid environmentally sensitive areas.

ROADS AND HIGHWAYS FINANCING

Malaysia achieved an average Gross Domestic Product growth of 9.5 % per annum for the period 1988 to 1996. The high economic growth during this period was accompanied by a structural transformation of the Malaysian economy, one from relying on production and export of primary commodities to a more modern industrial economy. Per capita income in nominal terms increased from RM 1,106 (US 300) in 1970 to RM 11,835 (US 4,000) in 1998. This higher than anticipated economic growth, enjoyed by Malaysia has resulted in road capacity constraints, as a result of a marked increase in vehicle ownership and usage. The government launched several strategies under its Second Outline Perspective Plan (1991 – 2000) where due emphasis is given to increasing capacities and improving efficiency through integrated and coordinated planning.

Today there are 1,238 km of toll expressways, 15,746 km of Non – toll Federal roads and 56,419 km of State Roads [5]. The major contributor in any road development is the Government. In this case the construction of road projects gets the full financing from the Government using public funds; from the initial project feasibility studies, planning, design, and construction including land acquisition.

Public – Private Partnering

Public – Private Partnering (PPP) is to be an effective approach in the provision of infrastructure needs. The PPP is where the implementation of projects is carried out by the private sector, promoting and encouraging in earnest by the government through its privatization policy. The involvement of the private sector has complemented the government's determined effort in developing and expanding the country's stock of infrastructure. In this respect, private companies are given the concession to obtain financing, both debt and equity, which is necessary to construct, operate and maintain the highways. Table 1 shows the investment by public and private sector in road development [6].

Role of Development Banks in Road Construction

Financial institutions such as the World Bank, Asian Development Bank (ADB) and other financial institutions can play a role in the road construction industry. Commercial banks are capable in committing funds up to 15 years or more depending on the concession periods agreed upon by the Government. The ADB has been reported to have participated in private financing of road sector. (Conference on “The 2003 Asian Roads and Highway”, 2003, Singapore). Seventy two (72) percent of loans from the ADB went to Transport Sector, three percent to airports and civil aviation, whilst ports/shipping and railway took up 10 and 15 percent respectively.

Schedule Tolling

This concept allows the construction of the expressways network. Tolling of the road takes in two forms. The construction of new roads requires road users to be charged for a certain rate for the journey traveled in order to finance the road projects. The initial costs of the construction will be through financial institution and in some part contribution from the Government in terms of advance payment for the acquisition of lands. As part of the loan repayment strategy road user toll is imposed to road users for part of the journey traveled. The approach seemed to be effective in accelerating construction of roads to add on the existing road network. However, this is found to be attractive on the only on the most economic routes. In any proposed investment the economic viability of the project will need to be carefully assessed in terms trip distribution and traffic growth on the proposed road and its impact on the neighboring network. Any 13 false indication or incorrect forecast of economic returns will jeopardize the overall construction of the investment.

Issues on why and when to invest on toll roads, and how investors and lenders evaluate projects are issues to be address before toll – highway projects can be financed. Investor's interest would mainly be focusing on project economies based on IRR and NPV and the payback analysis usually through toll charges. Challenges of start-up to toll-road projects highlights the necessity to rate toll road projects as a measure of relative risk profile, in timeliness of debt service payments, and to assess capital markets. It will provide the ability for project sponsors and financial advisers to consider various financing options.

Others Forms of Financing

The construction of roads can be from various sources of funding. In Malaysia the private sectors have the access to Pension Funds, Employees Provident Funds and more recently through public participation by way of listing of infrastructure project companies (IPC) on the Main Board of the Kuala Lumpur Stock Exchange to finance their highway projects.

NECESSITY OF QUALITY ASSURANCE

The main objectives of road construction are to provide a comfortable and save facility to the public particularly to the road user. With the huge amount of money spent for the construction of new roads, the understanding of necessity of achieving required construction quality is very much crucial in order to ensure the structural and the functionality of the constructed roads or facilities last within design life. In Malaysia, the quality assurance in the road construction very much covered at all level i.e. beginning from the planning, design and construction as well as during maintenance stage.

For instant, the requirement of having a proper planning is very important i.e. the road authority must carry out proper detail study on the proposed location in terms of overall event or development nearby as well as development of other agencies like housing and business that will link to the new proposed construction road.

Ideally in the design stage, the designer will consider all necessary aspects of the road geometry and structure of the pavement that comply with the approved design guideline, specification or technical notes. Upon compliance to these documents, the confident level of producing high quality of road will be achieved. But at certain circumstances i.e. budget constraint, certain criteria in the design especially which is related to the geometry has to be left out or compromised. This compromisation should be done carefully in order to avoid occurrence of lacking of safety aspect of the particular road.

Quality assurance during construction considered to be the most critical part in whole cycle of road construction. The compliance to specification must be assured by competent officer. Selection of good and experience contractor and consultant also the main factor that contributing to the quality product. The sense of responsibility toward producing good quality of road by all the project team will ensure production of the top class road. It is not an easy task because sometime outside influences such as political influence will affect the output quality of new constructed as well as in maintenance of existing road.

Guideline/Criteria

Until year 2007, the contract awarded for construction of new roads in Malaysia was based on the existing specification namely Standard Specification for Road Works (JKR/SPJ/1988). In the specification, typical quality assurance aspect such as construction materials and machineries has been stated in the contract document for every contract awarded. The range of quality assurance procedure will cover as early as in the preliminary works up to the post construction quality assurance tests. One of the main activities in the post construction test is the regularity test on the finish surface which covered in the Sub-Clause 4.4.3. The surface regularity should comply with the Table 2 below.

Beginning January 2009, the JKR particularly Road Facility Maintenance Branch was introducing new procedure of accepting new road project by establishing acceptance criteria. The acceptance criteria was covered all aspect in road components such as pavement, bridge, electrical as well as road furniture. This new criteria was discussed among branch which related to the road construction to ensure all parties agree to the requirement. Table below show the criteria set for the new constructed road.

Table 4.14 JKR/SPJ – Tolerances For Surface Irregularities

Class of Surface Regularity	Longitudinal Direction				Transverse Direction
	Maximum Permissible Number of Surface Irregularities				Maximum Permissible Depth of Transverse Irregularities mm
	Depth > 4mm		Depth > 7mm		
	over traverse length of 300m	over traverse length of 75m	over traverse length of 300m	over traverse length of 300m	
Class SR1	20	9	2	1	4
Class SR2	40	18	4	2	8
Class SR3	60	27	6	3	12
For Class SR1, no depths exceeding 10mm are permitted. For Classes SR2 & SR3, no depths exceeding 15mm are permitted.					

Table 2 : Tolerance For Surface Irregularities

Other than acceptance criteria, the implementation of auditing at various levels also being introduced to ensuring the quality and also to give the opportunity to other technical officers who's not directly involve in the construction, will be aware of the importance of compliance to required quality. The exercise will carry out continuously as early as in construction, defect liability period and finally during maintenance period.

Table 4 : Acceptance Criteria

A. Before CPC	
Pavement	▪ Longitudinal irregularity (shall comply with sub-section 4.4.3 JKR/SPJ/1988) ▪ Transverse irregularity (rut depth) ≤ 4 mm or The lane International Roughness Index (IRI) measured for the whole length and each 100 meter section shall be less than 2.0 m/km as per sub-section 4.5.3 JKR/SPJ/2008-S4) ▪ No crack ▪ No pothole ▪ No bleeding
Shoulder	▪ Flush and proper gradient from edge of pavement to RSD ▪ Pavement/shoulder difference ≤ 25 mm ▪ Irregularities (depression more than 150 mm) ≤ 1 m^2
Culvert	Major ▪ All culverts constructed as per drawings (no., size, type) ▪ Water flowing = 100%

	▪ Subsidence of adjacent pavement ≤ 10 mm Minor ▪ Debris in culvert ≤ 10 mm Water ponding inside culvert ≤ 10 mm ▪ Gap between joints ≤ 6 mm ▪ Condition Rating for each component/member = 1 or 2
Drainage	Major ▪ All drains constructed as per drawings (length, size, type) ▪ Water flowing = 100% Minor ▪ Debris in drain ≤ 10 mm ▪ Water ponding in drain ≤ 10 mm ▪ Gap between joints ≤ 6 mm
Slope	No slope failure
Bridge	Condition Rating for each component/member = 1 or 2
Mechanical & Electrical	Acceptance of testing & commissioning, witnessed by HOMT
Roadside Furniture	Constructed as per drawing and in accordance with Arahan Teknik
Road Safety Audit	RSA Stage 4 Part 3 has been carried out and action on all comments has been taken
B. <u>Before CMGD</u>	
Pavement	▪ Longitudinal irregularity (shall comply with sub-section 4.4.3 JKR/SPJ/1988) ▪ Transverse irregularity (rut depth) ≤ 4 mm ▪ No crack ▪ No pothole ▪ No bleeding
Shoulder	▪ Flush and proper gradient from edge of pavement to RSD ▪ Pavement/shoulder difference ≤ 50 mm ▪ Irregularities (depression more than 150 mm) ≤ 1 m^2
Culvert	Major ▪ Water flowing = 100% ▪ Subsidence of adjacent pavement ≤ 10 mm Minor ▪ Debris in culvert ≤ 10 mm ▪ Water ponding inside culvert ≤ 10 mm ▪ Gap between joints ≤ 6 mm Condition Rating for each component/member = 1 or 2
Drainage	Major ▪ Water flowing = 100% Minor ▪ Debris in drain ≤ 10 mm ▪ Water ponding in drain ≤ 10 mm ▪ Gap between joints ≤ 6 mm
Slope	No slope failure
Bridge	▪ Condition Rating for each component/member = 1 or 2 ▪ Subsidence of adjacent pavement ≤ 20 mm
Mechanical & Electrical	In working condition
Roadside Furniture	No fading/blemishes
Road Safety Audit	RSA Stage 5 has been carried out and action on all comments has been taken

Revision of the existing guideline i.e. Standard Specification for Road Works (JKR/SPJ/1988) was completed in 2008 and the new revised specification has been used for the new contract beginning March 2009. There are a few modification and additional item in the new specification like introduction of International Roughness Index (IRI) which is replacing the Rolling Straight Edge device for the surface regularity measurement.

Methodology/Equipment Used

As indicated in the specification, the measurement for the surface irregularity will use Rolling Straight-Edge and wedge and straight edge device. However, based on new released specification, the equipment used for the surface regularity has changed. The use of surface profiler (high speed or walking) is seems to be more accurate due to continuous survey along the new constructed road. There are three main road surface parameter can be translated from the surveyed profiler i.e. International Roughness Index (IRI), Sensor Measured Texture Depth (SMTD) and rut depth.

Figure 3 : 3m Rolling Straight Edge

Figure 4 : Straight Edge and Wedge

Figure 5 : Road Surface Profiler

CONCLUSION

The expansion of the road network in Malaysia has always been supply driven and evaluated by balancing the social obligation against economic returns, rather than on a demand driven basis. The supply driven road development plan has attracted a high cost of investment. The Government now faces the challenge to

ensure better quality investments and improve the methodologies for project selection and implementation.

Another emerging major issue related to road development policies that drives the implementation of the highway network development plan, is concerning the high financial cost to the Government resulting from implementation of fast-track projects through deferred payment schemes and BOT toll highways that did not perform well.

In the case of deferred payment projects, the choice of improving the highway network either through the upgrading and widening of the existing facilities or by the construction of a totally new highway must be carefully balanced by social and economical considerations as both tend to have almost similar financial development costs. Both options have advantages and disadvantages in the long-term planning of the highway network.

A few BOT toll highways turned out to have much lower traffic volume and required further government intervention. The compensations that must be paid by the Government to concession companies to keep the toll rates at affordable 14 levels are becoming a fiscal burden and will invariably require renegotiation of terms with the concession companies. The success of future BOT projects will depend on reliable future traffic demand forecasts, affordable toll rates, and sound mechanism of financing schemes.

Good quality of new constructed road can be achieved by taking into consideration of all quality aspects in the road construction cycle beginning from planning, designing as well as in the construction stages.

Road safety issues have been progressively addressed in the road development plans to reduce accident rates and fatalities. The number of fatalities in road accidents per 10,000 registered vehicles in Malaysia is 4.9 deaths in 2003. While addition allocation has been provided under the accident black spot mitigation programme and conduct of Road Safety Audits, there is a need to set up a revolving fund to finance future road safety enhancement programmes to achieve the government’s target of reducing road accident fatalities to 3 deaths per 10,000 vehicles by 2010.